PRELIMINARY REPORT OF A SURVEY TO MEASURE THE IMPACT OF THE MOUNTAIN PINE BEETLE IN A LODGEPOLE PINE FOREST

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Preliminary Report of a Survey to Measure the Impact of the Mountain Pine Beetle in a Lodgepole Pine Forest

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ABSTRACT

During the past two decades, the mountain pine beetle has seriously depleted the lodgepole pine forests of the Intermountain West. Using 35mm color aerial photography, a double sampling system, and permanently established plots, measurements of stand depletion were made in a 120,222-acre management area on the Targhee National Forest, Idaho, in 1972-73. Additional to measurements of standing live and beetle-killed timber, data was also obtained on reproduction, forage yield, habitat type, disease (mistletoe), and other factors that will yield insight into the effects of mountain pine beetle damage on other forest resources. A remeasurement of all plots in 1975 showed that although there was some additional tree mortality, there was a net increase in both lodgepole and total stand volume. Plans are to remeasure these plots at periodic intervals as a base (model) for predicting future yield.

INTRODUCTION

During the past 20 years the mountain pine beetle, Dendroctonus ponderosae Hopk., has killed untold quantities of lodgepole pine, and to a far lesser extent, ponderosa, whitebark, and limber pine in the Intermountain Region. Starting in 1967, efforts were made to measure the effects of both ongoing and culminated mountain pine beetle outbreaks in terms of numbers of trees and volumes killed. These data as well as some of the methods used to procure that data, more or less set the stage for the present study. Since most of these data were taken from widely separated and somewhat limited locales, we needed to obtain meaningful information from a larger, more representative area such as a working circle, management unit, or possibly a Ranger District. The selection process included three important critera: first, the infestation had to be recently terminated; second, the survey area must contain other significant and measurable resources other than timber; and third, the area also had to be small and homogeneous enough that it could be effectively and efficiently sampled, but large enough that whatever changes occurred, they would impact management decisions and practices. Although not a criteria in area designation, one additional requirement of considerable importance, was that whatever sampling system used, it must be permanent and

conducive to remeasurement. Not only did we need to know the in situ damage caused by the mountain pine beetle, but it was imperative that we continue to monitor the growth characteristics of the residual forest to determine its recuperative abilities.

AREA AND HISTORY

The impact area, covering 120,222 acres including 86,000 acres of lodgepole pine type is in the Ashton (formerly Porcupine) Ranger District of the Targhee National Forest, Idaho. Roughly, the boundaries run from Cave Falls road and the southern boundary of Yellowstone National Park on the north, south to the North Fork of the Teton River, east to the Divide, and west to the Forest boundary (Figure 1). Elevations range from 5,700 feet in the west to 7,500 feet in the east.

The Porcupine area came under attack by the mountain pine beetle during the early 1960's, peaked during the period from 1967 to 1969, then rapidly declined. Infestation movement was generally from southwest to northeast. Control efforts in part of the area, using the individual tree standing spray method, was started in 1964, continued for three consecutive years, then stopped. Logging for salvage is now underway along the western portion of the area.

PURPOSE

The purpose of this impact survey is to measure the changes in a lodgepole pine forest caused by an outbreak of the mountain pine beetle, and attempt to relate these changes and their effect, whatever, on people, the environment, and the economy. The intent is to follow or monitor the change in stand dynamics, including the dead as well as living components, as a base for determining the forest's recuperate rate and potential yield.

PLANNING

Preliminary survey plans were started in 1971 and completed in the spring of 1972.[1/] On April 24, 1972, a meeting was held in Ogden to brief personnel representing a variety of disciplines and interests on the purpose of the survey and to request their advise and/or assistance on survey methodology and procedures. Response ranged from keen interest and active participation to indifference.

1/ Preliminary working guide on the conduct of a survey to determine the impact of the mountain pine beetle in lodgepole pine, 1972. 9 pp.

REPORTING

This is the first in a series of reports with the intent being to document survey methodology and to describe in a general way the 1972-73 and 1975 surveys on stand structure impact and short term changes. Hopefully, in a few cases, these data will either suffice for some interpretation and analysis, or provide a base on which additional supporting data can be obtained.

METHODS

The basis for the survey was a multi-stage sampling system using 35mm color aerial photography, photo ground truth, and a variety of on-the-ground sampling methods (Figure 2). In 1971, sixty stereo triplets at a scale of 1:5000 were taken from a light aircraft in a grid pattern approximately 1-1/2 miles apart. A 4-acre-square plot was delimited in the center of the overlap area of the best stereo pair and examined stereoscopically for dead lodgepole pine. These plots served as the base for the following sampling practices:

Ground Truth. To obtain a correlation between the photo mortality estimates and the actual ground counts, all dead lodgepole pine 5-inches dbh and larger were recorded on 21 randomly selected plots (Figure 1). Additionally, as a check on photo scale, one border of the plot was measured with a topographic tape and clinometer.

Stand Structure. A variable plot (baf 10) was established in the center of each 4-acre plot. All tree species 5-inches dbh and over, living or dead[1/], were recorded starting north in a clockwise direction. Most plots were established in 1972 while a few were established in 1973.

1. All "in" lodgepole pines, living or dead, were marked at dbh with numbered, metal tags.

2. Total height and live crown ratio were measured and recorded for the first three live "in" lodgepole pines.

3. All "in" lodgepole pines were rated as to incidence and degree of mistletoe using the Hawksworth classification system.

4. Increment cores were taken at dbh from the first three "in" live and dead lodgepole pines.

5. Crown density estimates using a spherical densiometer (Model C) were taken at plot center.

1/ All dead lodgepole pine was assumed to be killed directly or indirectly by the mountain pine beetle.

Reproduction and Saplings. All reproduction (6-inches high to 1.5-inches at root collar) and saplings (1.6-inches to 4.5-inches dbh) were recorded on five, 1/300-acre circular plots, one at variable plot center, and the other four a distance of 1/2-chain in cardinal directions. There was measurement discrepancy, however, between the 1972-73 and 1975 surveys. In 1972-73 the upper diameter limit for seedlings and saplings was 0.99 and 4.99-inches respectively. In 1975 these were changed to coincide with the lower diameter limit for poles, 4.6-inches dbh.

Recreation Study. Since the impact area contained only one developed recreation area, Cave Falls Campground, this phase of the survey was extended to include two heavily used campgrounds (Signal Mountain and Coulter Bay) and a popular hiking trail (Taggart Lake) in adjacent Grand Teton National Park. These areas also incurred heavy beetle damage during the late 1960's and early 1970's but have since declined. In 1973 both variable plot and strip cruises were run in each area to record total tree mortality by diameter, but in the Taggart Lake sample, only those trees that were within range of the trail were recorded.

Site Study A 50 x 100 foot rectangular site classification plot was established in the center of the 4-acre plot. Data was taken on species occurrence and abundance, plant community types and herbage yield. A field-going herbarium of most of the plant species was assembled for training purposes and future reference.

Soil Pits. Soil pits were dug near each plot center but this practice was abandoned near the end of the 1972 season because of a lack of expertise, i.e., a qualified soil scientist.

Photo Points. In 1972-73 a single 35mm color photo was taken of each site study plot with the focal point being plot center. In 1975 single as well as stereo photos were taken.

RESULTS

Lodgepole Pine Mortality. Tree mortality was estimated two ways: by aerial photography interpretation, and by the variable plot method.

Estimates of lodgepole pine killed by the mountain pine beetle per acre follows:

Method	>5-inches dbh	>7-inches dbh
Aerial Method	113.2	71.3
Variable Plot	97.7	79.6

Considering the high level of mortality, there was generally good agreement between the two sampling methods. For the aerial photo portion the r^2 values for all trees and those 7-inches dbh and greater were 0.80 and 0.94, respectively; the reason for the difference being quite simply that the larger trees (>7-inches dbh) are more visible on the photos than the smaller trees (Figure 3). Conversely, it is probable that some small trees (>5-inches dbh), especially those open grown and not obscured by the overstory, were also identified on the aerial photos. It is believed that the aerial photo method best describes the overall tree losses as well as diameter distribution, but both methods are closely in accord with trees greater than 10-inches dbh (Figure 4).

Stand Structure. The stand structure following the outbreak in 1972-73 and again in 1975 is shown in Tables 1 and 2 and Figures 5 and 6. Initial stand mortality of lodgepole pine 9-inches dbh and greater amounts to 62 percent of the trees and 65 percent of the volume for the lodgepole component and 56 percent of the trees and 55 percent of the volume for the stand.

There is very little overall difference between the two sampling periods other than a few trees (approximately 6 per acre) continued to die, mostly from windthrow. Ingrowth practically made up this difference. One significant change was a decrease of approximately 8 trees per acre in the 6-inch class. This may have been due to ingrowth, suggesting that the small, young trees are more susceptible to release.

The differences in the two cruises is more significant when the data are converted to volume (Tables 3,4,5,6; Figure 7). A summary of these volume differences is thus:

	Bd. Ft. Volume 5-inches Dbh and Greater								
	Lodgepole Pine			Other Species			Total		
Year	Live	Dead	Total	Live	Dead	Total	Live	Dead	Total
1975	5103	7050	12153	1797	173	1970	6900	7223	14123
1972	4894	6110	11004	1705	835	2540	6599	6945	13544
Diff.	+209	+940	+1149	+92	-662	-570	+301	+278	+579

The significant factor here is that although some trees, particularly lodgepole pine, continue to die (mostly windthrow and secondary insects), there was a net increase of 301 bd. ft. per acre, with the lodgepole component increasing by more than 200 bd. ft. Now that the stand has stabilized somewhat, future gains should continue to far exceed the losses.

The implications of this tree mortality on forest fire hazard and management is evident. These data will be converted to tons of fuel per acre as a criteria for on-the-ground fuel loading and other fire hazard classifications.

Reproduction and Saplings. A summary of this understory component for the 1972-73 and 1975 surveys is shown in Table 7 and Figures 8 and 9. The overall level of stocking for lodgepole pine and other species is more than adequate but there is a large variation in both distribution and abundance between areas. Some type of supplemental stand examination will be required to specifically identify those areas that may be inadequately stocked or need conversion.

The minor difference in stocking levels for the various tree species between the initial and followup surveys is not understood at this time, but possible causes could be the shift in size categories and sampling variation.

The relatively high sapling mortality of lodgepole pine (47 per acre in 1975) was due to secondary bark beetles, particularly Ips spp. These and other secondary beetles of lesser impact typically follow in the aftermath of a mountain pine beetle outbreak, attacking and killing mostly the smaller trees.

Recreation Study. Tables 8 through 10 show the tree mortality that has occurred in the two campgrounds and along the Taggart Lake trail in Grand Teton National Park. Briefly, tree kill in Signal Mountain and Coulter Bay Campgrounds were 47 and 40 percent respectively, while mortality along the Taggart Lake trail was 34 percent. Since the infestation was still in progress, but on the decline, total mortality will be somewhat higher. Felling and removal of dead trees is still in progress in the two campgrounds, as well as in other campgrounds in the Park. Plans are now to assign a hazard probability to the trees contiguous to the Taggart Lake trail.

Site Study. This analysis is incomplete at this time but it is hoped that the data will yield worthwhile information on the relationship between habitat type and tree growth rates. The plant classification and abundance data, coupled with crown density, may provide insight into present and future forage capacity. Some additional field classification may be necessary to identify questionable habitat types.

DISCUSSION

The preliminary results reported herein stem from only a fraction of that data collected during the survey. It is compiled here to show the drastic and obvious changes in a lodgepole pine forest caused by the mountain pine beetle. These data include changes in stand structure, species abundance and composition, volume, reproduction and other readily measurable factors that will aid in the identification of major impact areas. Further compilation of existing data such as growth rates, mistletoe incidence, habitat relationships, and fuel loading; and the collection of additional, corraborative data including recreation use trends, stream flow records (Falls River), changes in road, trail, and fence management practices and costs, and their analysis and interpretation will be incorporated into the next report. In the meantime, however, it is hoped that the information contained in this report will provide the base upon which the final analysis can be built.

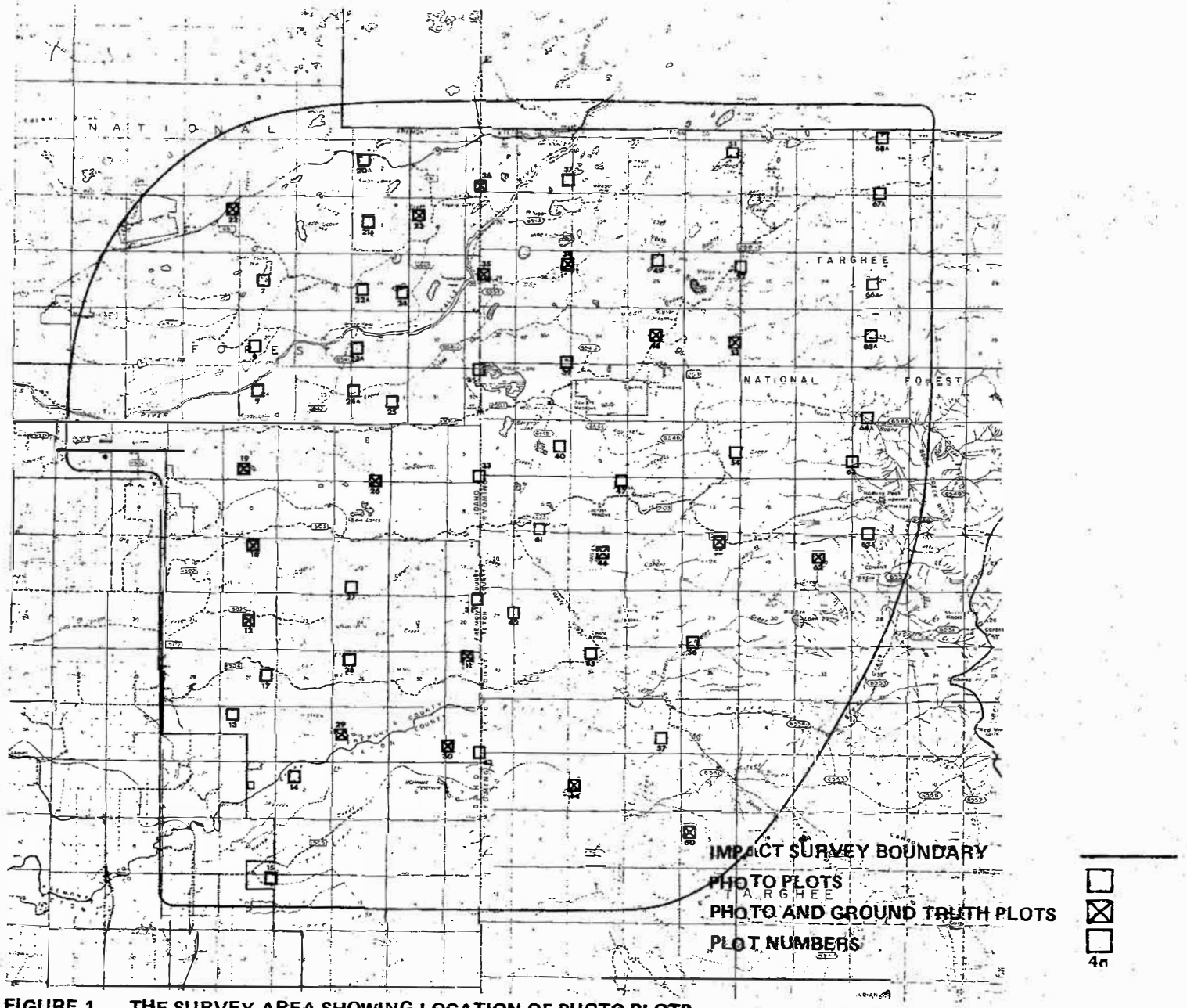
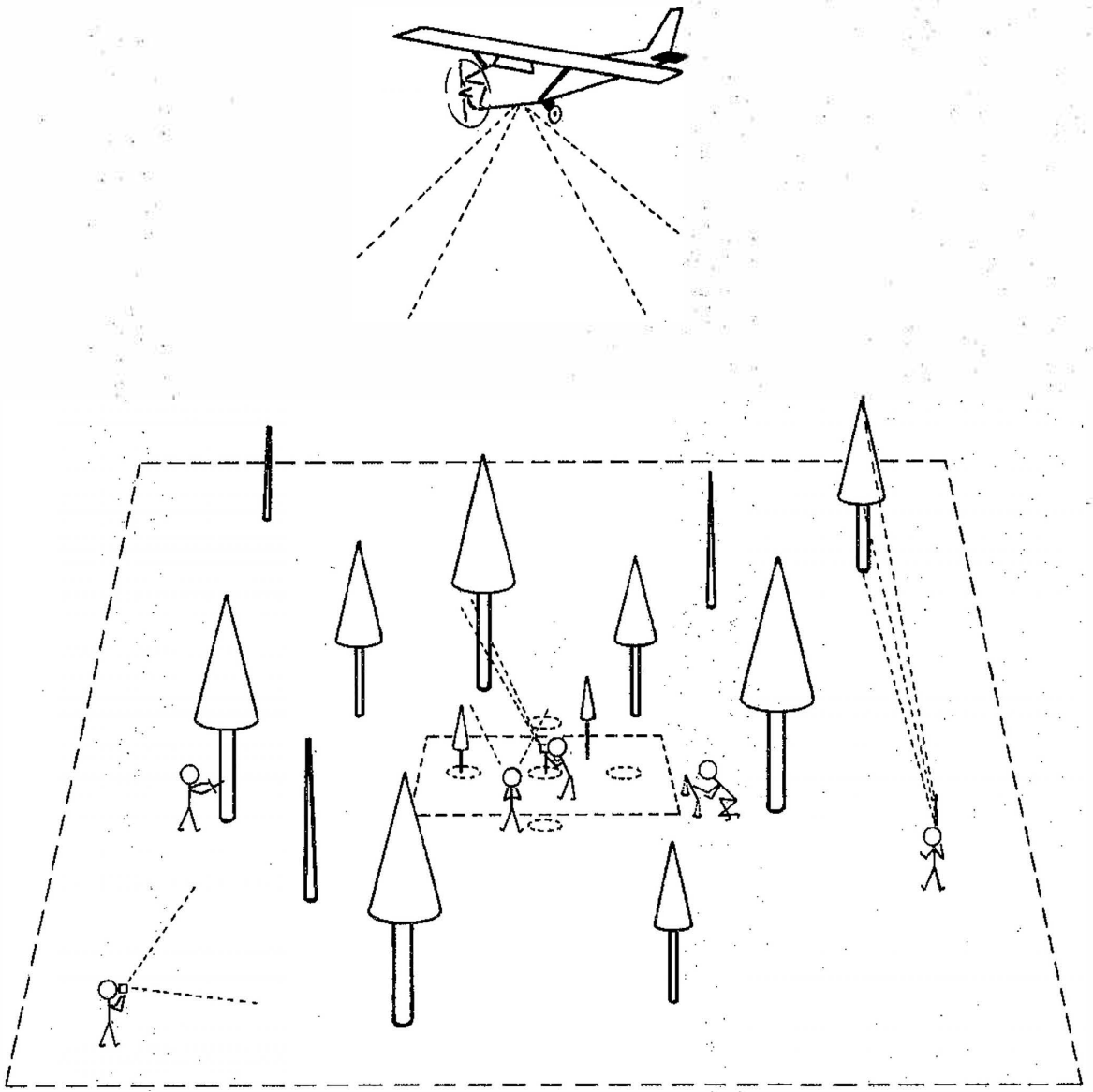


FIGURE 1. THE SURVEY AREA SHOWING LOCATION OF PHOTO PLOTS



- 4-ACRE MORTALITY (AERIAL & GROUND TRUTH)
- 50' x 100' HABITAT PLOT
- STAND STRUCTURE (BAF 10)
- REPRODUCTION
- TREE HEIGHT
- LIVE CROWN RATIO
- CROWN DENSITY
- INCREMENT BORING
- MISTLETOE RATING
- GROUND PHOTO

FIGURE 2. THE BASIC PLOT SAMPLING DESIGN

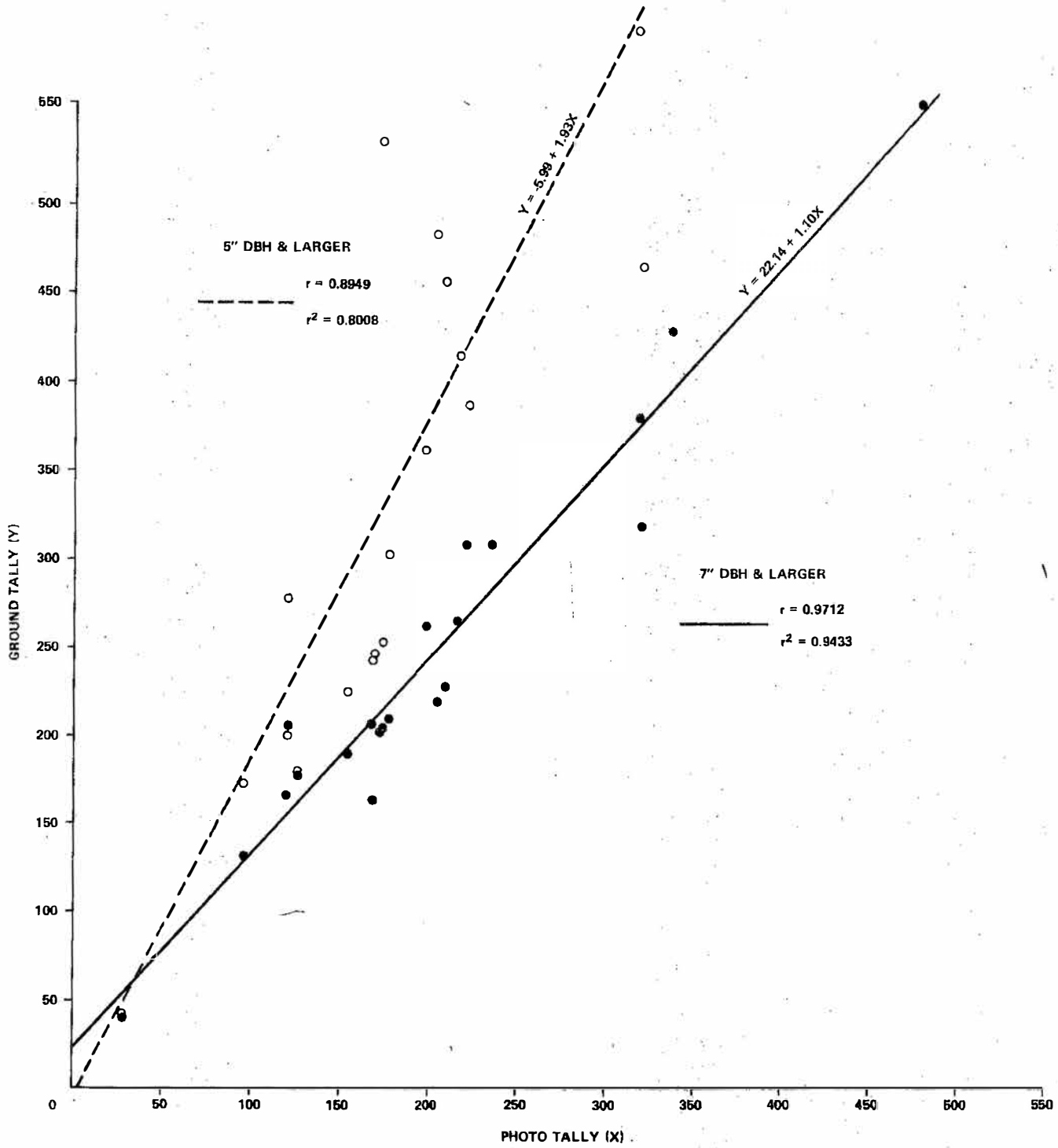


FIGURE 3. REGRESSION ANALYSIS - GROUND TALLY TO PHOTO TALLY FOR LODGEPOLE PINE KILLED BY MOUNTAIN PINE BEETLE

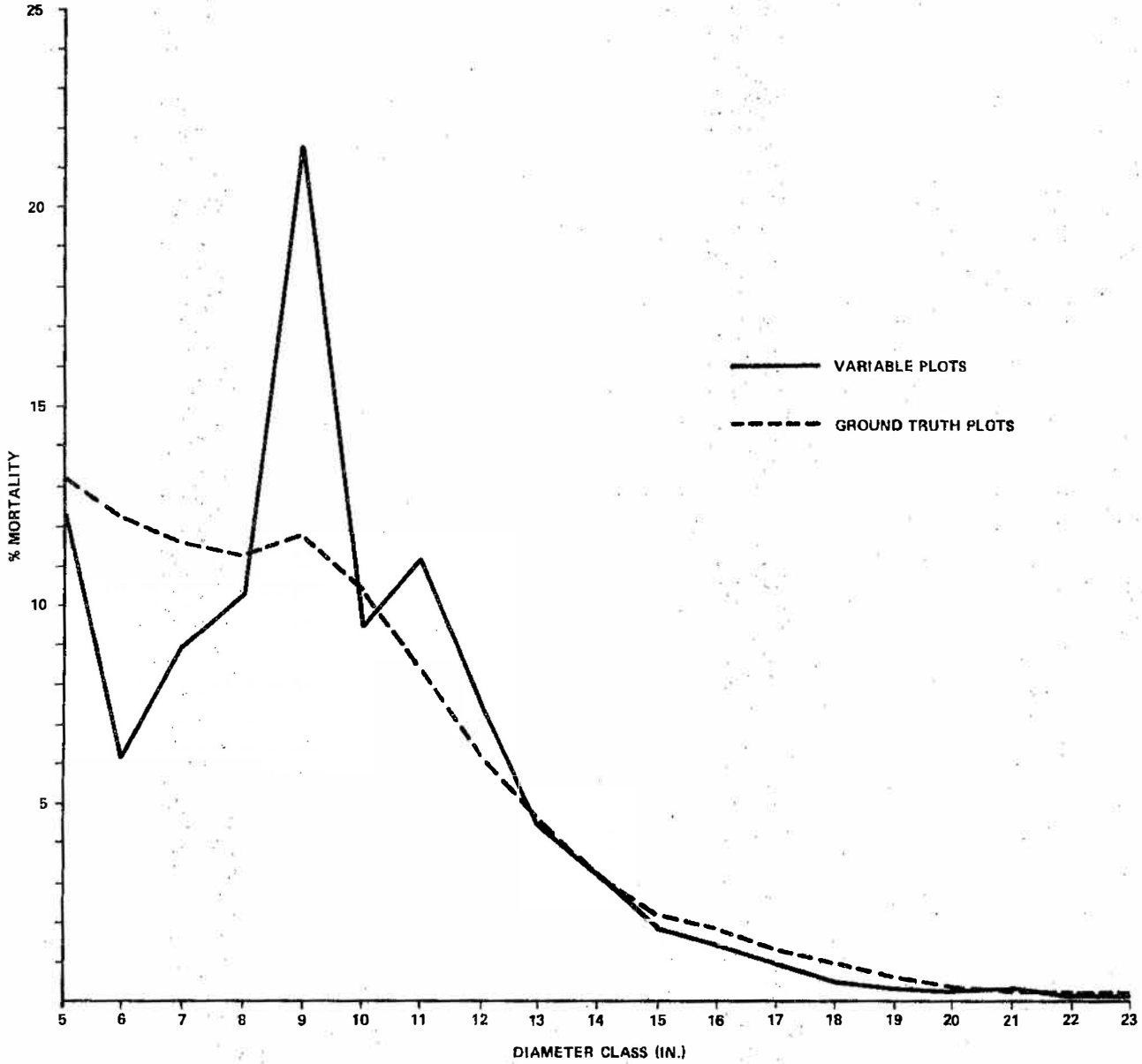


FIGURE 4. COMPARISON OF MORTALITY BY DIAMETER CLASS - AERIAL PHOTO GROUND TRUTH PLOTS VS VARIABLE PLOTS FOR LODGEPOLE PINE KILLED BY MOUNTAIN PINE BEETLE

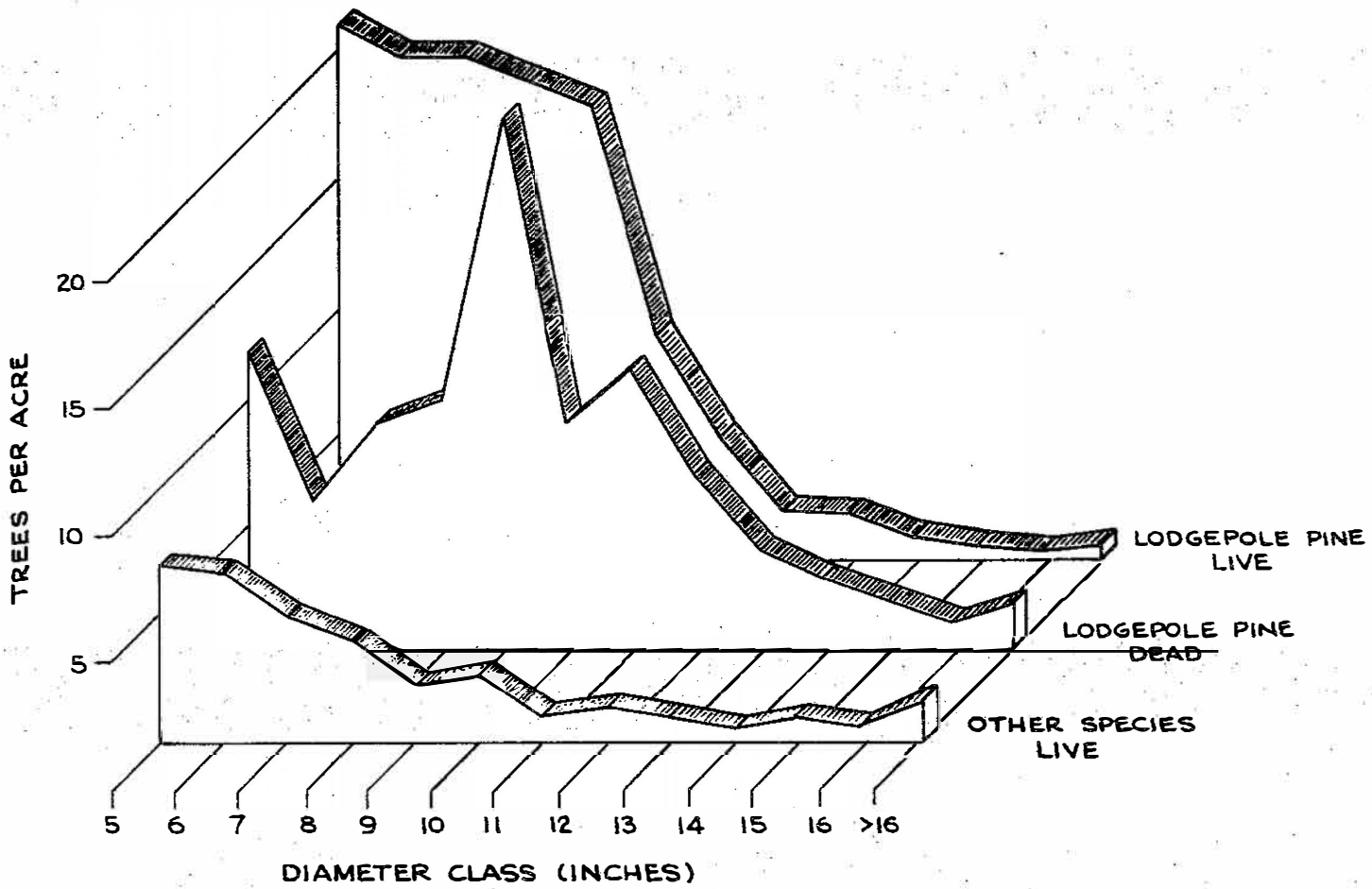


FIGURE 5. STAND STRUCTURE OF LODGEPOLE PINE FOREST FOLLOWING AN OUTBREAK OF THE MOUNTAIN PINE BEETLE, 1972

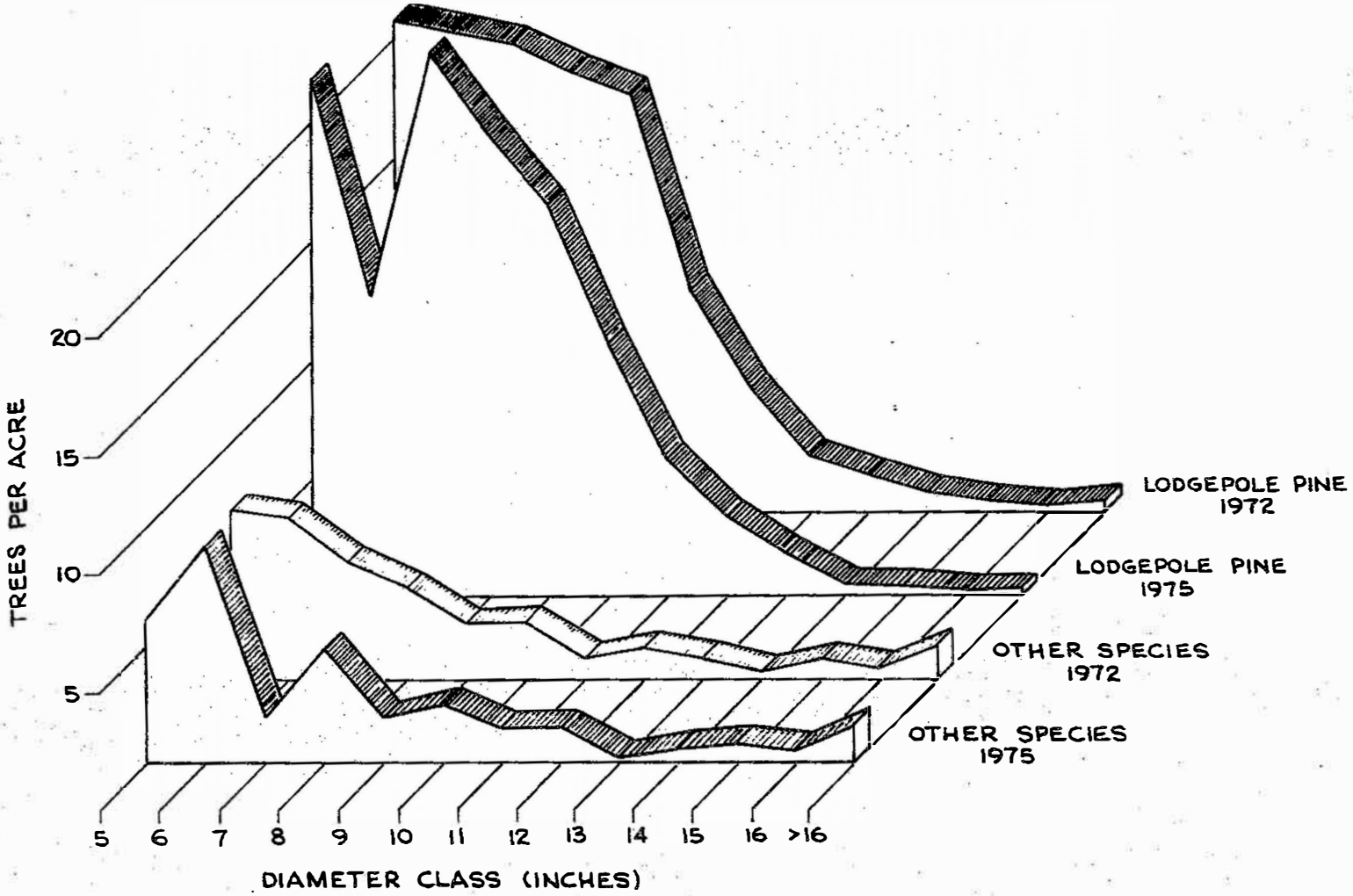


FIGURE 6. COMPARISON OF STAND STRUCTURE OF MOUNTAIN PINE BEETLE DEPLETED LODGEPOLE PINE FOREST FOLLOWING AN OUTBREAK, 1972, AND THREE YEARS LATER, 1975

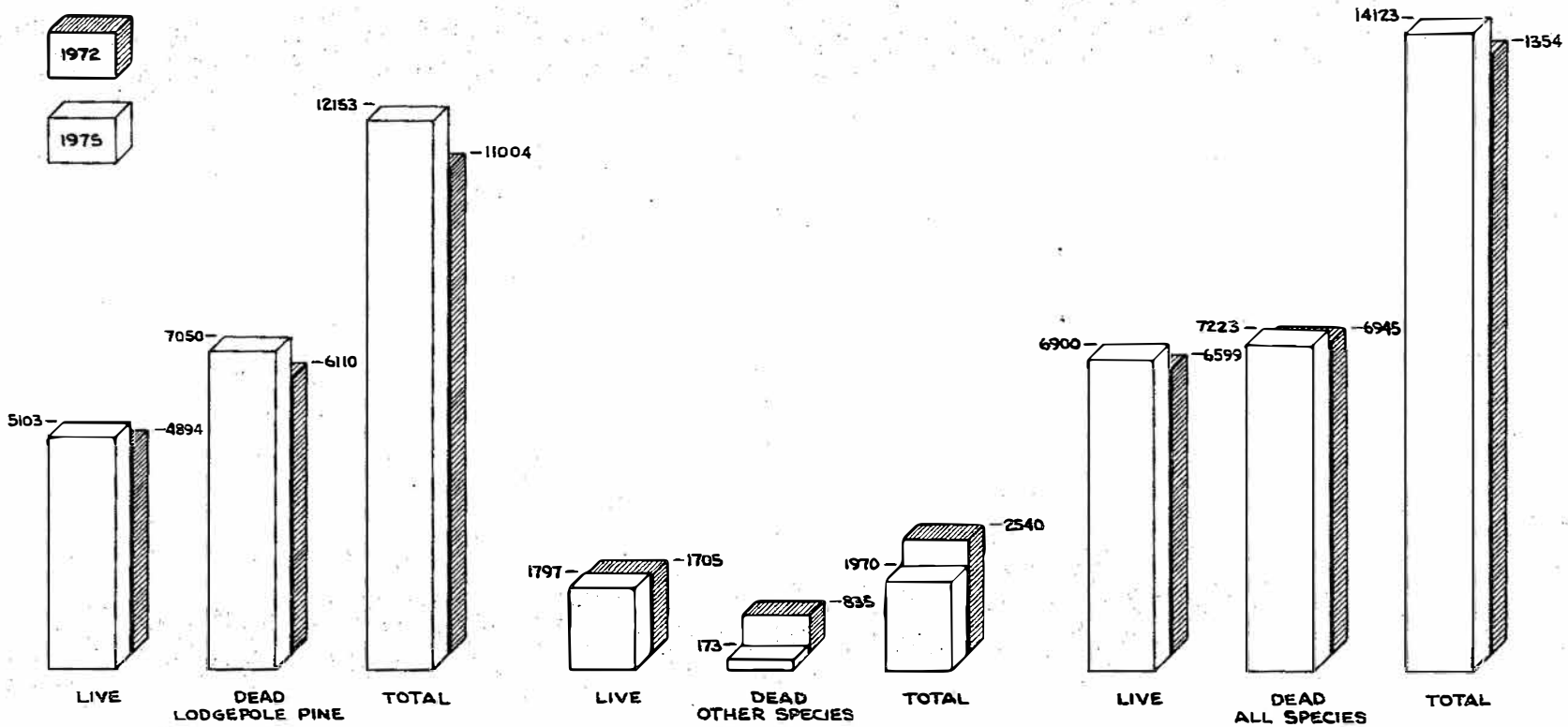


FIGURE 7. COMPARISON OF BOARD FOOT VOLUME (>5-INCHES DBH) OF MOUNTAIN PINE BEETLE DEPLETED LODGEPOLE PINE FOREST FOLLOWING AN OUTBREAK, 1972, AND THREE YEARS LATER, 1975

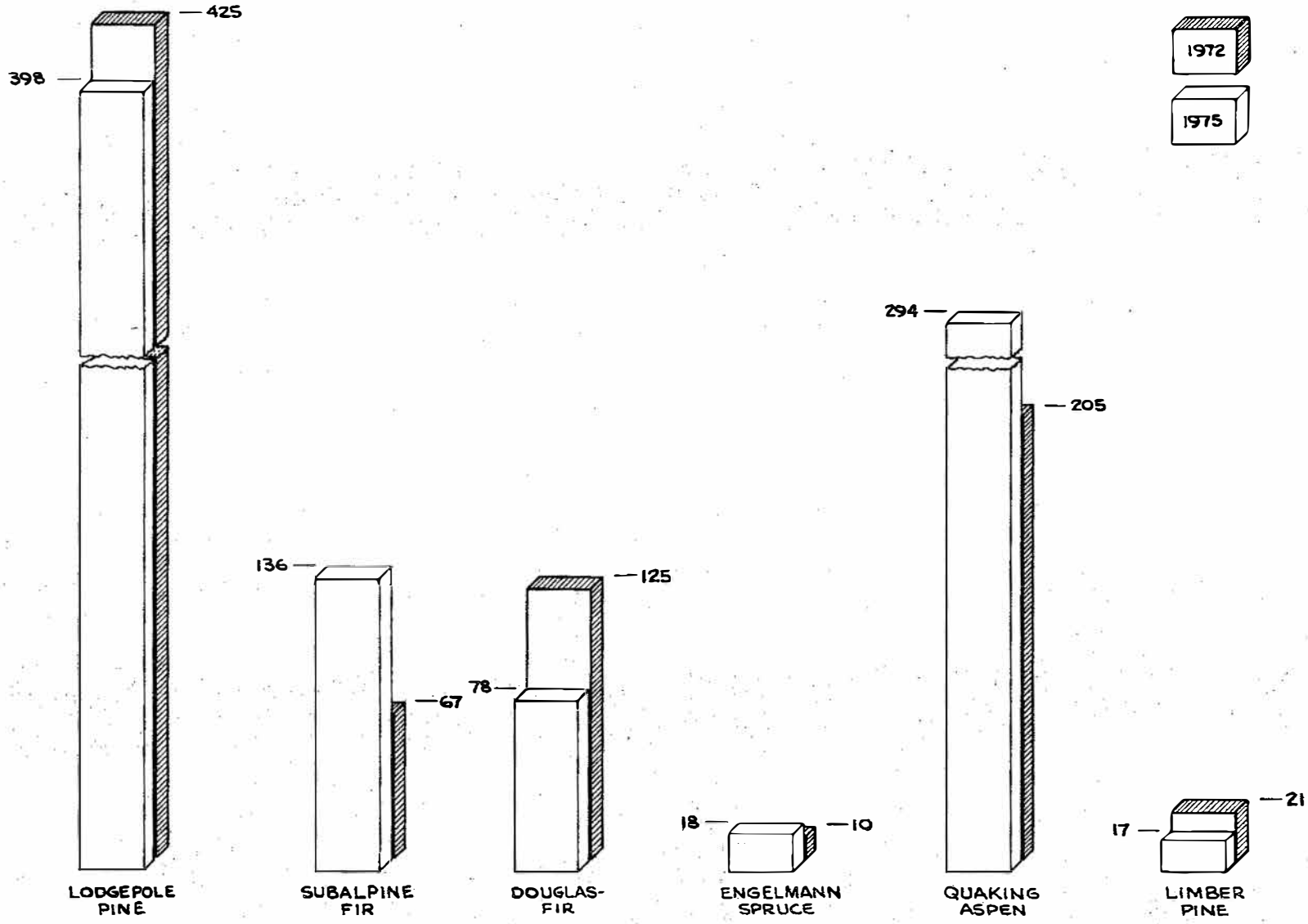


FIGURE 8. COMPARISON OF SEEDLING STOCKING (6-INCH HIGH TO 1.5-INCHES) IN MOUNTAIN PINE BEETLE DEPLETED FOREST FOLLOWING AN OUTBREAK, 1972, AND THREE YEARS LATER, 1975

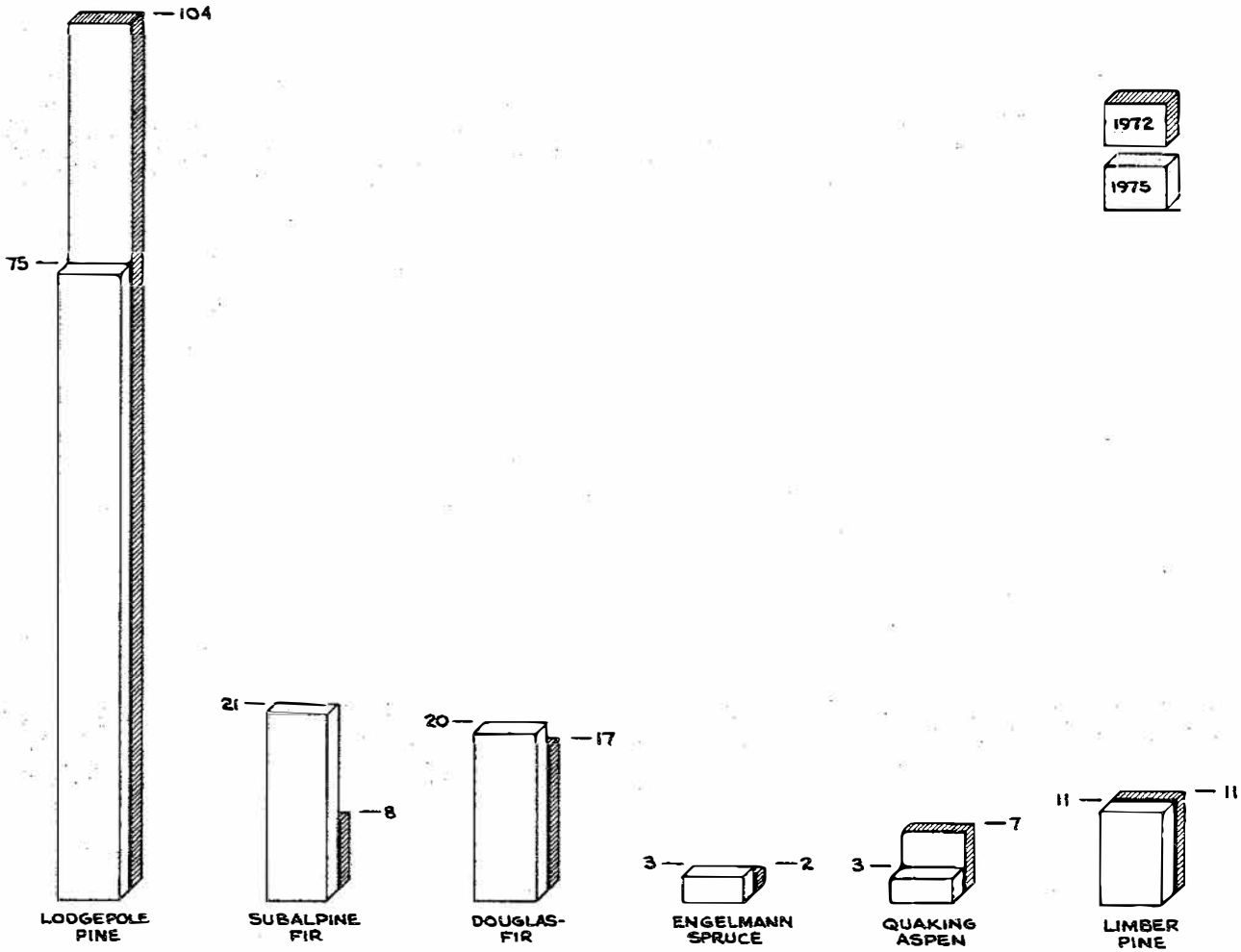


FIGURE 9. COMPARISON OF SAPLING STOCKING (1.6 TO 4.5 INCHES) IN MOUNTAIN PINE BEETLE DEPLETED FOREST FOLLOWING AN OUTBREAK, 1972, AND THREE YEARS LATER, 1975

Table 1. Stand structure (trees per acre) of a lodgepole pine forest following a mountain pine beetle outbreak, Targhee National Forest, 1972.

Area	Diam. Class	Trees per Acre							
		LODGEPOLE PINE				OTHER SPP.[2]		TOTAL	
		Live		Dead		Live		All spp.	
	(In.)	(No.)	(%)[1]	(No.)	(%)[1]	(No.)	(%)[1]	(No.)	(%)[1]
Porcupine	5	20.8	8.2	12.2	4.8	8.6	3.3	41.6	16.3
Targhee N. F.	6	20.4	8.0	5.9	2.3	6.8	2.7	33.1	13.0
	7	19.9	7.8	8.7	3.4	6.9	2.7	35.5	13.9
Basal Area/acre	8	18.6	7.3	10.0	3.9	5.3	2.1	33.9	13.3
	9	17.7	6.9	21.1	8.3	2.6	1.0	41.4	16.2
Live Lpp. 40.0	10	9.2	3.6	9.2	3.6	2.7	1.1	21.1	8.3
Dead Lpp. 51.2	11	5.1	2.0	10.8	4.2	1.3	0.5	17.2	6.7
Other Spp. 15.7	12	2.3	0.9	7.2	2.8	1.5	0.6	11.0	4.3
	13	1.6	0.6	4.3	1.7	0.9	0.4	6.8	2.7
Total 106.9	14	0.8	0.3	3.1	1.2	0.5	0.2	4.4	1.7
	15	0.3	0.1	1.8	0.7	1.1	0.4	3.2	1.2
	16	0.1	0.1	1.3	0.5	0.7	0.2	2.1	0.8
	> 16	0.3	0.1	2.1	0.8	1.6	0.7	4.0	1.6
TOTAL		117.1	45.9	97.7	38.2	40.5	15.9	255.3	100.0

[1] Percent of total stand

[2] Douglas-Fir, Subalpine Fir, Engelmann Spruce, Limber Pine, and Quaking Aspen

Table 2. Stand structure (trees per acre) of a lodgepole pine forest following a mountain pine beetle outbreak, Targhee National Forest, 1975.

Area	Diam. Class	Trees per Acre							
		LODGEPOLE PINE				OTHER SPP.[2]		TOTAL	
		Live		Dead		Live		All spp.	
	(In.)	(No.)	(%)[1]	(No.)	(%)[1]	(No.)	(%)[1]	(No.)	(%)[1]
Porcupine	5	22.0	8.5	14.7	5.6	6.1	2.3	42.8	16.4
Targhee N. F.	6	12.7	4.9	6.8	2.6	11.0	4.2	30.5	11.7
	7	23.1	8.9	8.7	3.3	3.1	1.2	34.9	13.4
Basal Area/Acre	8	19.6	7.5	11.0	4.2	6.2	2.4	36.8	14.1
	9	16.6	6.4	21.5	8.3	2.3	0.8	40.4	15.5
Live Lpp. 41.3	10	10.7	4.1	9.2	3.5	2.7	1.0	22.6	8.6
Dead Lpp. 15.8	11	5.8	2.2	11.6	4.5	1.8	0.7	19.2	7.4
Other Spp. 15.8	12	3.4	1.3	7.2	2.8	2.1	0.8	12.7	4.9
	13	1.8	0.7	4.3	1.6	0.4	0.2	6.5	2.5
Total 109.9	14	0.5	0.2	3.1	1.2	0.9	0.3	4.5	1.7
	15	0.4	0.2	1.8	0.7	1.0	0.4	3.2	1.3
	16	0.1	0.1	1.3	0.5	0.7	0.3	2.1	0.9
	> 16	0.2	0.1	2.2	0.8	1.7	0.7	4.1	1.6
TOTAL		116.9	45.1	103.4	39.6	40.0	15.3	260.3	100.0

[1] Percent of total stand

[2] Douglas Fir, Subalpine Fir, Engelmann Spruce, Limber Pine, and Quaking Aspen

Table 3. Stand structure (volume per acre) of a lodgepole pine forest following a mountain pine beetle outbreak, Targhee National Forest, 1972.

Area	Diam. Class	Volume per Acre Scribner							
		LODGEPOLE PINE				OTHER SPP.[2]		TOTAL	
		Live		Dead		Live		All spp.	
	(In.)	(Bd. Ft.)	(%)[1]	(Bd. Ft.)	(%)[1]	(Bd. Ft.)	(%)[1]	(Bd. Ft.)	(%)[1]
Porcupine	5	499	3.9	252	1.9	63	0.6	814	6.4
	6	480	3.8	140	1.1	36	0.3	656	5.2
	7	455	3.6	168	1.3	60	0.5	683	5.4
	8	669	5.3	272	2.1	77	0.6	1018	8.0
	9	925	7.3	873	6.9	61	0.5	1859	14.7
	10	643	5.1	588	4.6	126	1.0	1357	10.7
	11	419	3.3	791	6.2	66	0.5	1276	10.0
	12	311	2.4	788	6.2	106	0.8	1205	9.4
	13	213	1.7	528	4.1	85	0.7	826	6.5
	14	124	1.0	496	3.9	68	0.5	688	5.4
	15	60	0.5	296	2.3	162	1.3	518	4.1
	16	14	0.1	257	2.0	135	1.1	406	3.2
	> 16	82	0.6	661	5.2	660	5.2	1403	11.0
TOTAL		4894	38.6	6110	47.8	1705	13.6	12709	100.00

[1] Percent of total stand

[2] Douglas-fir, Subalpine Fir, Engelmann Spruce, Limber Pine, and Quaking Aspen.

Table 4. Stand structure (volume per acre) of a lodgepole pine forest following a mountain pine beetle outbreak, Targhee National Forest, 1975.

Area	Diam. Class	Volume per Acre Scribner							
		LODGEPOLE PINE				OTHER SPP.[2]		TOTAL	
		Live		Dead		Live		All spp.	
	(In.)	(Bd. Ft.)	(%)[1]	(Bd. Ft.)	(%)[1]	(Bd. Ft.)	(%)[1]	(Bd. Ft.)	(%)[1]
Porcupine	5	560	4.0	308	2.2	18	0.1	886	6.3
	6	300	2.2	160	1.2	80	0.6	540	4.0
	7	531	3.8	210	1.5	29	0.2	770	5.5
	8	720	5.2	352	2.5	68	0.5	1140	8.2
	9	854	6.1	1142	8.2	57	0.4	2053	14.7
	10	762	5.5	630	4.5	144	1.0	1536	11.0
	11	477	3.4	1009	7.2	109	0.8	1595	11.4
	12	394	2.8	816	5.9	160	1.2	1370	9.9
	13	241	1.7	576	4.1	39	0.3	856	6.1
	14	76	0.6	503	3.6	142	1.0	721	5.2
	15	85	0.6	325	2.3	144	1.0	554	3.9
	16	38	0.3	286	2.0	135	1.0	459	3.3
	> 16	65	0.5	733	5.2	672	4.8	1470	10.5
TOTAL		5103	36.7	7050	50.4	1797	12.9	13950	100.00

[1] Percent of total stand

[2] Douglas-fir, Subalpine Fir, Engelmann Spruce, Limber Pine, and Quaking Aspen.

Table 5. Stand structure of non-host trees (volume per acre) of a lodgepole pine forest following a mountain pine beetle outbreak, Targhee National Forest, 1972.

Area	Diam. Class	Volume per Acre Scribner									
		Douglas-fir		Subalpine Fir		Engelmann Spruce		Quaking Aspen		Total Non-host	
		Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
	(In.)	(Bd. Ft.)		(Bd. Ft.)		(Bd. Ft.)		(Bd. Ft.)		(Bd. Ft.)	
Porcupine	5	24	-	24	-	-	-	15	-	63	28
	6	16	-	20	-	-	-	-	-	36	-
	7	30	-	9	-	-	-	21	-	60	28
	8	20	-	24	-	-	-	33	-	77	64
	9	45	-	-	-	-	-	16	-	61	220
	10	72	-	19	-	17	-	18	-	126	63
	11	28	-	-	-	-	-	38	19	66	129
	12	64	-	21	-	-	-	21	-	106	48
	13	85	-	-	-	-	-	-	-	85	72
	14	-	-	22	-	-	-	46	-	68	-
	15	114	-	-	-	24	-	24	-	162	25
	16	60	-	-	-	25	-	50	-	135	26
	> 16	541	100	23	-	70	-	26	-	660	132
TOTAL		1099	100	162	-	136	-	308	19	1705	835

[1] Includes data gathered only as "other species"

Table 6. Stand structure of non-host trees (volume per acre) of a lodgepole pine forest following a mountain pine beetle outbreak, Targhee National Forest, 1975.

Area	Diam. Class	Volume per Acre Scribner									
		Douglas-fir		Subalpine Fir		Engelmann Spruce		Quaking Aspen		Total Non-host	
		Live	Dead	Live	Dead	Live	Dead	Live	Dead	Live	Dead
	(In.)	(Bd. Ft.)		(Bd. Ft.)		(Bd. Ft.)		(Bd. Ft.)		(Bd. Ft.)	
Porcupine	5	-	-	18	-	-	-	-	-	18	-
	6	32	-	28	-	-	-	20	-	80	-
	7	6	-	9	-	-	-	14	-	29	-
	8	30	-	16	-	-	-	22	-	68	-
	9	27	-	14	-	-	-	16	-	57	-
	10	73	-	17	-	18	-	36	-	144	-
	11	70	-	-	-	20	-	19	19	109	19
	12	80	16	21	-	-	-	59	-	160	16
	13	17	-	-	-	-	-	22	-	39	-
	14	72	-	22	-	-	-	48	-	142	-
	15	95	-	-	-	24	-	25	-	144	-
	16	60	-	-	-	25	-	50	-	135	-
	> 16	567	138	23	-	62	-	20	-	672	138
TOTAL		1129	154	168	-	149	-	351	19	1797	173

Table 7. Summary of reproduction survey, Targhee National Forest, 1972-73 and 1975.

		Seedlings		Saplings			
				Live		Dead	
Year	Species	Trees/acre	%	Trees/acre	%	Trees/acre	%
1972-73	Lodgepole Pine	425.0	49.8	104.0	69.4	35.0	66.0
	Subalpine Fir	67.0	7.9	8.0	5.3	0.0	0.0
	Douglas-fir	125.0	14.6	18.0	12.0	8.0	15.1
	Engelmann Spruce	10.0	1.2	2.0	1.3	0.0	0.0
	Quaking Aspen	205.0	24.0	7.0	4.7	10.0	18.9
	Limber Pine	21.0	2.5	11.0	7.3	0.0	0.0
	All Species	853.0	100.0	150.0	100.0	53.0	100.0
1975	Lodgepole pine	398.0	42.3	75.0	56.4	47.0	75.8
	Subalpine Fir	136.0	14.5	21.0	15.8	1.0	1.6
	Douglas-fir	78.0	8.3	20.0	15.0	6.0	9.7
	Engelmann Spruce	18.0	1.9	3.0	2.3	0.0	0.0
	Quaking Aspen	294.0	31.2	3.0	2.3	8.0	12.9
	Limber Pine	17.0	1.8	11.0	8.2	0.0	0.0
	All Species	941.0	100.0	133.0	100.0	62.0	100.0

Table 8. Stand structure (trees per acre) of a lodgepole pine stand following a mountain pine beetle outbreak, Signal Mountain Campground, Grand Teton National Park, 1973.

Area	Diam. Class	Trees Per Acre											
		Lodgepole Pine								Other Spp.		Total All Spp.	
		Live		Dead		Stumps		Total Dead		Live			
	(In.)	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])
Signal	5	37.5	9.6	37.5	9.6	12.5	3.2	50.0	12.8	0	0	87.5	22.4
Mountain	6	42.4	10.8	10.6	2.7	0.0	0.0	10.6	2.7	0	0	53.0	13.5
Campground	7	21.8	5.6	10.9	2.8	1.6	0.4	12.5	3.2	0	0	34.3	8.8
	8	20.3	5.1	25.1	6.4	6.0	1.5	31.1	7.9	0	0	51.4	13.0
Basal Area/Acre:	9	79.2	20.2	25.5	6.5	1.9	0.5	27.4	7.0	0	0	106.6	27.2
Live Lpp - 60.4	10	3.8	1.0	22.9	5.8	3.1	0.8	26.0	6.6	0	0	29.8	7.6
Dead Lpp - 57.9	11	1.3	,0.3	17.7	4.5	1.3	0.3	19.0	4.8	0	0	20.3	5.1
Stumps - 7.1	12	0.0	0.0	4.2	1.1	0.0	0.0	4.2	1.1	0	0	4.2	1.1
Other Spp. - 0	13	0.0	0.0	3.2	0.8	0.5	0.1	3.7	0.9	0	0	3.7	0.9
Total - 125.4	14	0.0	0.0	1.2	0.3	0.4	0.1	1.6	0.4	0	0	1.6	0.4
Total		206.3	52.6	158.8	40.5	27.3	6.9	186.1	47.4	0	0	392.4	100.0

[1] Percent of total stand

Table 9. Stand structure (trees per acre) of a lodgepole pine stand following a mountain pine beetle outbreak, Coulter Bay Campground, Grand Teton National Park, 1973.

Area	Diam. Class	Trees Per Acre											
		Lodgepole Pine								Other Spp.[2]		Total All Spp.	
		Live		Dead		Stumps		Total Dead		Live			
	(In.)	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])
Coulter	5	45.5	19.3	0.0	0.0	0.0	0.0	0.0	0.0	36.4	15.5	81.9	34.8
Bay	6	20.1	8.5	6.2	2.6	0.0	0.0	6.2	2.6	0.0	0.0	26.3	11.1
Campground	7	6.8	2.9	9.1	3.9	2.3	1.0	11.4	4.9	1.1	0.5	19.3	8.3
	8	11.3	4.8	6.1	2.6	1.7	0.7	7.8	3.3	0.0	0.0	19.1	8.1
Basal Area/Acre:	9	6.9	2.9	7.5	3.2	2.1	0.9	9.6	4.1	0.7	0.3	17.2	7.3
Live Lpp - 21.8	10	6.1	2.6	15.0	6.4	4.4	1.8	19.4	8.2	0.6	0.3	26.1	11.1
Dead Lpp - 40.6	11	3.7	1.6	11.0	4.7	1.8	0.8	12.8	5.5	0.5	0.2	17.0	7.3
Stumps - 15.4	12	1.2	0.5	5.4	2.3	1.5	0.6	6.9	2.9	0.0	0.0	8.1	3.4
Other Spp.[2] - 2.4	13	0.3	0.1	7.6	3.1	3.9	1.7	1.5	4.8	0.0	0.0	11.8	4.9
Total - 80.2	14	0.6	0.3	2.3	1.0	2.0	0.8	4.3	1.8	0.0	0.0	4.9	2.1
	15	0.0	0.0	0.7	0.3	1.2	0.5	1.9	0.8	0.0	0.0	1.9	0.8
	16	0.0	0.0	0.9	0.4	0.4	0.2	1.3	0.6	0.0	0.0	1.3	0.6
	17	0.0	0.0	0.2	0.1	0.0	0.0	0.2	0.1	0.0	0.0	0.2	0.1
	18	0.0	0.0	0.0	0.0	0.3	0.1	0.3	0.1	0.0	0.0	0.3	0.1
Total		102.5	43.5	72.0	30.6	21.6	9.1	93.6	39.7	39.3	16.8	235.4	100.0

[1] Percent of total stand

[2] Subalpine Fir and Engelmann Spruce

Table 10. Stand structure (trees per acre) of a lodgepole pine stand following in mountain pine beetle outbreak, Taggart Lake Trail, Grand Teton National Park, 1973.

Area	Diam. Class	Trees Per Acre							
		Lodgepole Pine				Other Spp.[2]		Total All Spp.	
		Live		Dead		Live			
	(In.)	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])	(No.)	(%[1])
Taggart	5	61.8	20.8	35.3	11.9	17.6	5.9	114.7	38.6
Lake	6	15.0	5.0	7.5	2.5	4.5	1.5	27.0	9.0
Trail	7	19.8	6.7	7.7	2.6	6.6	2.2	34.1	11.5
	8	14.3	4.8	6.7	2.3	3.4	1.1	24.4	8.2
Basal Area/Acre:	9	11.3	3.8	10.0	3.4	4.7	1.7	26.0	8.9
	10	9.7	3.3	8.6	2.9	6.5	2.2	24.8	8.4
Live Lpp. - 33.2	11	4.5	1.5	5.3	1.8	2.7	0.9	12.5	4.2
Dead Lpp. - 43.8	12	1.5	0.5	4.1	1.4	1.9	0.6	7.5	2.5
Other Spp.[2] - 22.1	13	1.3	0.4	3.5	1.2	3.5	1.2	8.3	2.8
Total - 99.1	14	0.3	0.1	2.8	0.9	1.9	0.6	5.0	1.6
	15	0.2	0.1	3.8	1.3	1.2	0.4	5.2	1.8
	16	0.4	0.1	1.3	0.4	0.4	0.1	2.1	0.6
	17	0.6	0.2	0.4	0.1	0.4	0.1	1.4	0.4
	18	0.2	0.1	1.2	0.4	0.3	0.1	1.7	0.6
	19	0.0	0.0	2.8	0.9	0.1	0.0	2.9	0.9
Total		140.9	47.4	101.0	33.9	55.7	18.7	297.6	100.0

[1] Percent of total stand

[2] Douglas-fir, Subalpine Fir, Quaking Aspen, and Engelmann Spruce